



U.S. Army Research, Development and
Engineering Command



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Blast Technologies

Mark Germundson

Ground System Survivability – Systems Integration

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Blast Technology Development



- ***Develop occupant centric vehicle design & test standards for ground vehicles***
- ***Create occupant centric system-level protection against blast, crash and rollover injuries***
- ***Develop tools and capabilities for quicker assessment of new technology for rapid implementation and fielding***
- ***Support PM and theater requests for system level assessment of occupant and underbody protection technologies***



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TARDEC's Blast Technology Resources



- ***Blast Technology – 20+ people dedicated***
 - *From component level to vehicle systems integration*
- ***Blast M&S – 10+ people dedicated***
- ***Partner with other government agencies, industry and academia***
- ***Lab/ Facilities***
 - *Sub System Drop Tower*
 - *Head Impact Protection Lab within next 6 months*
 - *Vertical Accelerative Tower within next 18 months*
 - *High Performance Computer Center (M&S)*
 - *Other lab and test facilities within TARDEC and Government*

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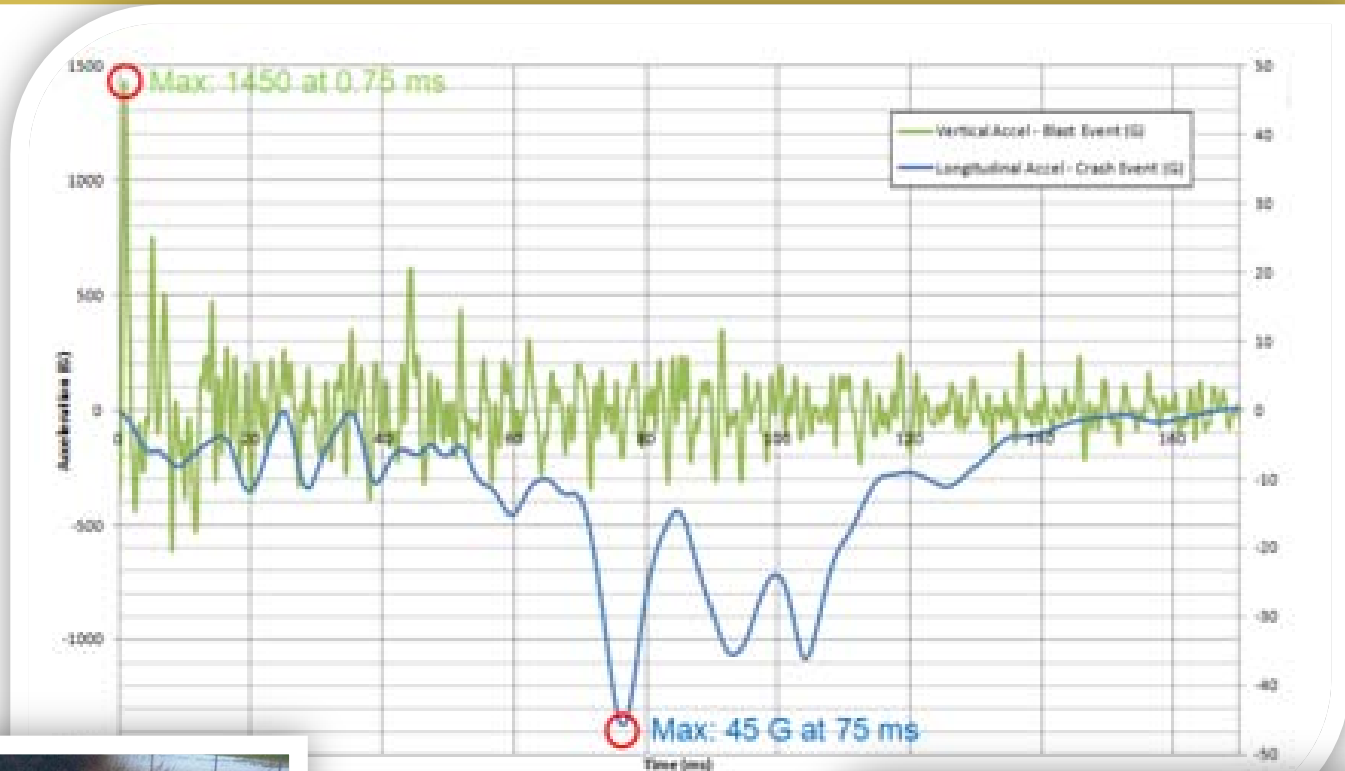
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Issues

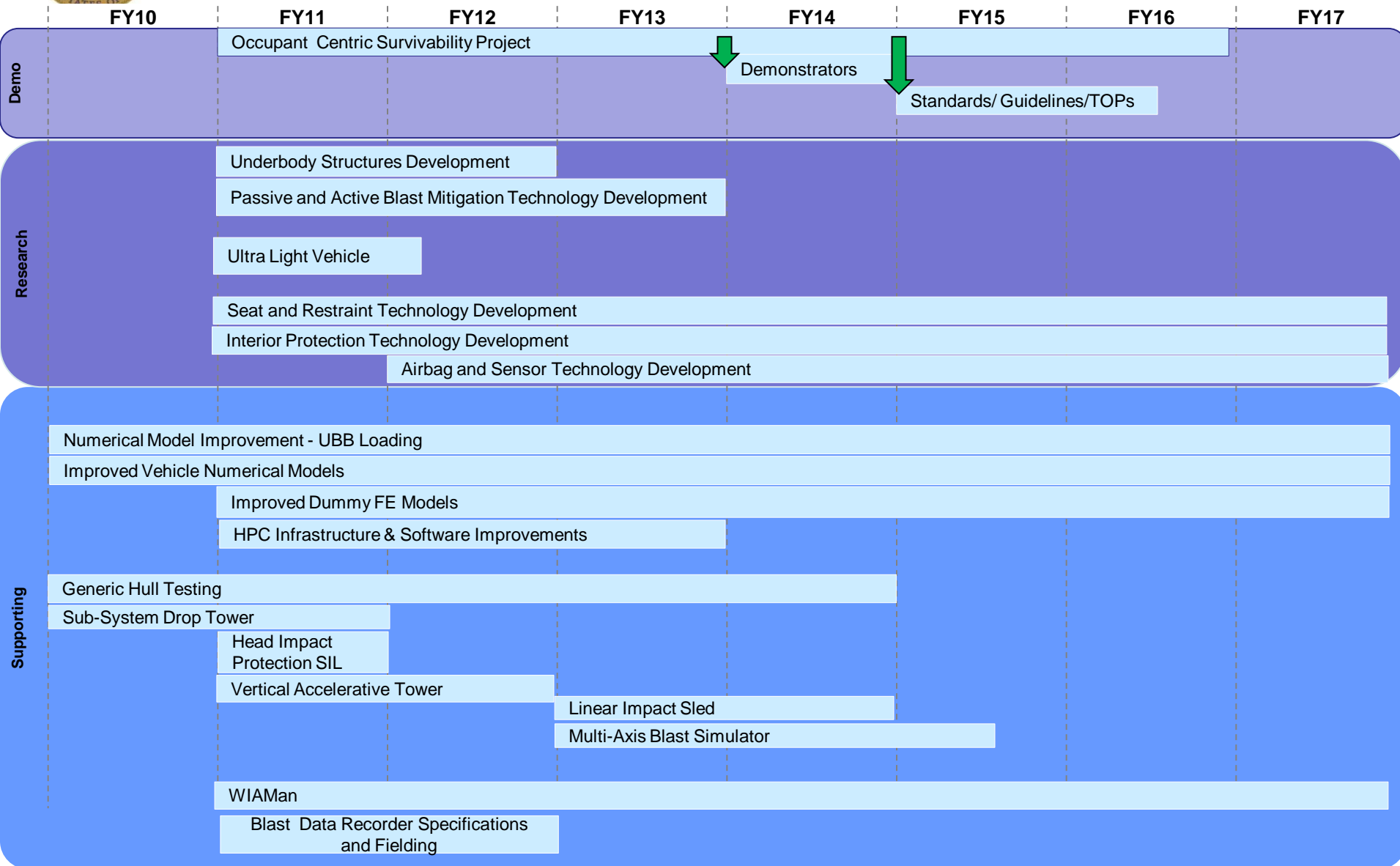


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Ground Vehicle Occupant Protection Efforts



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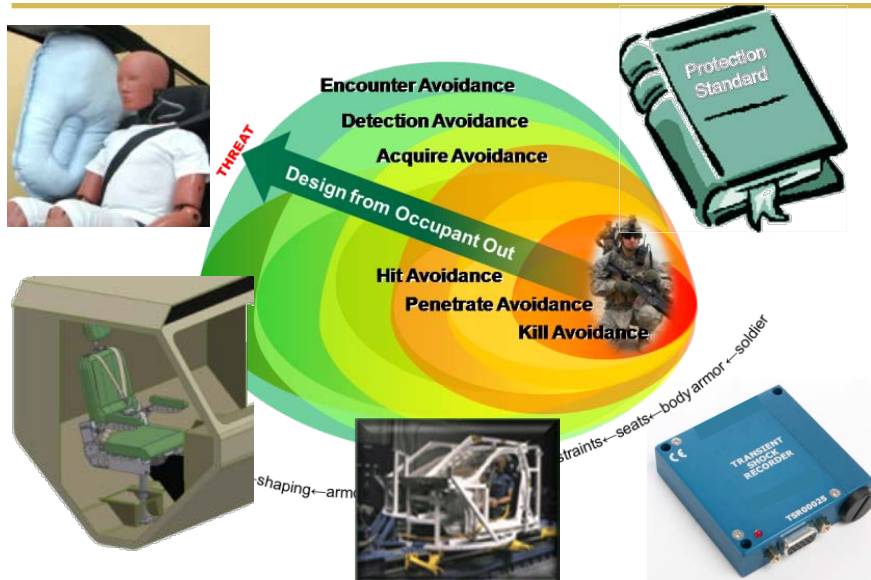
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Ground Systems Survivability Blast Technologies



Purpose:

- ❑ Approach occupant protection from a system level; leverage defense, automotive/race industry, & medical community knowledge to integrate IED/mine, crash and rollover protection. Continue development of Modeling & Simulation (M&S) capability to predict and reconstruct mine/IED/crash events.

Products:

- ❑ Advanced occupant protection technologies including, blast deflecting underbody solutions, energy absorbing seat designs, airbag and restraint systems, and energy absorbing flooring solutions
- ❑ Vehicle event data recorders for collecting highly accurate event data to be utilized for the development of robust test procedures to replicate in-theater events and resultant countermeasures to mitigate Warfighter injuries
- ❑ High fidelity system-level vehicle models which are capable of modeling crash, rollover and blast events
- ❑ Enhanced test and evaluation capability through the development of labs capable of repeatable representation of the inputs caused by mines/IEDs and crash/rollover events

Payoffs:

- ❑ Creates and develops infrastructure, physical and virtual tools, and technologies for enhanced occupant protection for ground vehicle systems.

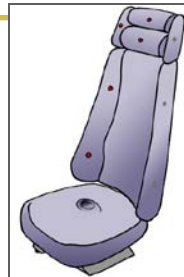
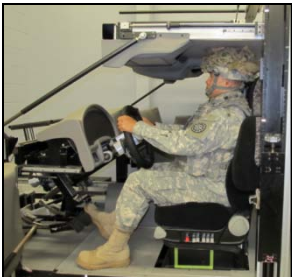
	12	13	14	15	16	17
Occupant Protection Technology Development						
- Interior						
- Exterior						
- Sensor/Instrumentation						
Modeling and Simulation Tools Enhancement						
System Evaluation Lab						

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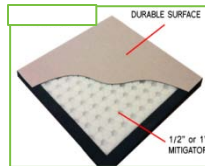
Interior and Sensor Technology Development



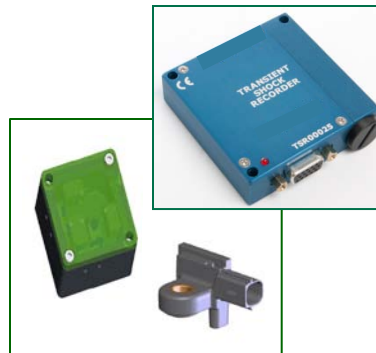
Novel Seat and Restraint Designs focused on the Warfighter's mission



Posture Studies to Support Seat and Restraint Development



Energy Absorbing Materials



Data Recorders and Sensors

Purpose:

- ❑ Interior Technology and Sensors provide the mechanism to evaluate, optimize, integrate, and validate occupant centric survivability and safety systems to mitigate injury due to blast, crash and rollover events.

Requirements:

- ❑ Upgrade the ground fleet with interior and sensors for blast mitigation for improved occupant protection. Provide accurate on-board post blast/crash data collection techniques and recording equipment.

Products:

The test equipment simulates blast & crash events and evaluates the occupant and protection system response to these forces.

- ❑ Blast attenuating seats that are resettable and have off-axis stroking capability.
- ❑ Restraints that simultaneously protect and better compliment the Warfighter's mission during multiple vehicle events.
- ❑ Alternative energy absorbing floor mats and interior treatments.
- ❑ Airbag or comparable technologies such as bolsters.
- ❑ Sensors that can detect and deploy/trigger interior treatments within the timeframe of a blast event and will not inadvertently activate.
- ❑ Vehicle data recorders for vehicle and event diagnostics and prognostics.
- ❑ Devices that are more receptive to usage in theater.
- ❑ Test methodology and standards for ground vehicle energy interior and sensor technology development and evaluation for blast, crash, rollover and side IED events.

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Energy Absorbing Seats w/ Restraints						
Blast Mats and other Interior Treatments						
Data Recorders and Sensors						
Methods and Standards Development						



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Exterior Technology/Underbody



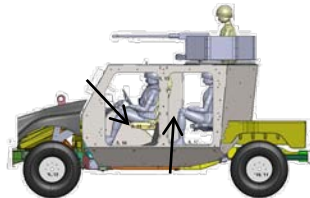
Underbody Optimization and Integration



Live Fire Test and Evaluation



Energy Absorbing (EA) Materials and Structures



Full Vehicle Blast Mitigation



Reconfigurable Underbody Test Buck

Purpose:

- ❑ Exterior Technology and Underbody provide the mechanism to evaluate, optimize, integrate, and validate occupant centric survivability and safety systems to mitigate injury due to blast and crash events.

Requirements:

- ❑ Upgrade the tactical and combat ground fleet with exterior and underbody blast mitigating technologies to include structural systems.

Products:

- ❑ Generic Hull Test Buck: To provide data to industry and verify various blast mitigating concepts
- ❑ Reconfigurable Underbody Test Buck: Quick turn-around and flexible cab/underbody testing device. Adjustable to various cab and underbody configurations. To be utilized to gather internal and external systems data.
- ❑ Full Vehicle Blast Mitigation: Evaluation of structures in combination with vehicle systems and other blast mitigating technologies for research and the PM.
- ❑ Active Blast Concepts: Evaluate blast countermeasure concepts and blast sensing.
- ❑ Energy Absorbing (EA) Materials: Support industry/SBIR partnerships in advancing the state-of-the-art in integrated EA materials.

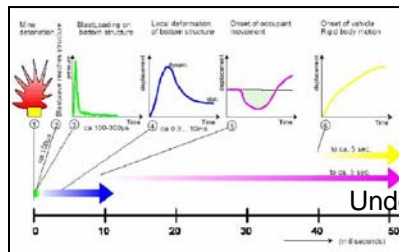
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EA Materials & Structures						
Underbody Optimization & Integration						
Full Vehicle Blast Mitigation						
Live Fire Test and Evaluation						
Reconfigurable Underbody Testing						

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Underbody Blast Modeling & Simulation



Purpose:

- ❑ Enhance full system , End-to-End, M&S capability in order to reduce program risk, occupant injury and uncertainty in integration designs.

Requirements:

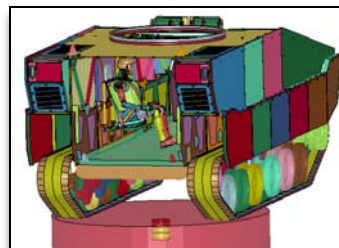
- ❑ Upgrade the tactical and combat ground fleet with interior, exterior, and underbody blast mitigating technologies to include structural systems.

Products:

- ❑ **Software/High Performance Computing Infrastructure:** To meet significant growth in demand for computational services from PEO/PM.
- ❑ **Occupant Finite Element Models:** Improve occupant injury models (FE ATD and Human models).
- ❑ **Full Vehicle End-to-End M&S Models:** Full vehicle underbody blast M&S capability to provide program risk reduction and increased confidence during modernization development phase and Live Fire Test & Evaluation.
- ❑ **Underbody Blast Loading:** To predict transient underbody loading for mine/IED events.



Occupant Finite Element Models



Full Vehicle End-to-End M&S Models



High Performance Computing Infrastructure

	12	13	14	15	16	17
Expanded High Performance Computing						
Full Vehicle End-to-End Models						
Occupant Finite Element Models						
Underbody Blast Loading						

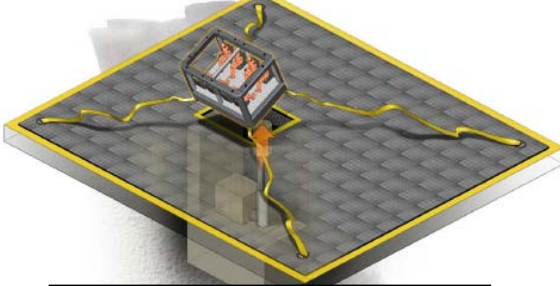
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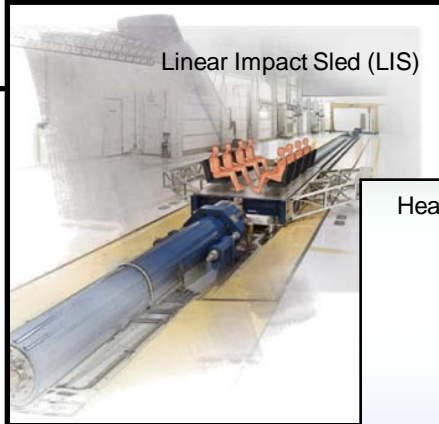
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Occupant Protection Systems Integration Laboratories

Multi-Axis Blast Simulator (MABS)



Linear Impact Sled (LIS)



Vertical Accelerative Tower (VAT)



Head Impact Protection (HIP)



Purpose:

- ☐ The OP SIL provides the mechanism to evaluate, optimize, integrate, and validate occupant centric survivability and safety systems to mitigate injury due to blast and crash events.

Products:

The test equipment simulates blast & crash events and evaluates the occupant and protection system response to these forces.

- ☐ MABS: Underbelly blast events at system level
- ☐ LIS: Front & side impact, side IED, and rollover
- ☐ VAT: Vertical forces and floor deformation
- ☐ HIP: Head protection systems

Payoff:

MABS

- ☐ State-of-the-art unique piece of test equipment
- ☐ Reduced number of LFT&E (~LFT&E \$75,000 - \$150,000; MABS ~\$15,400)

LIS

- ☐ Multiple crash events evaluated on one test device
- ☐ System design optimization for multiple impacts

VAT

- ☐ Assess multiple occupants & lower extremity injury
- ☐ Configurable platform - vehicle specific layout

HIP

- ☐ Low cost, quick assessment of a head impact protection
- ☐ Assess interior padding solutions

	12	13	14	15	16	17
Head Impact Protection						
Vertical Accelerative Tower						
Linear Impact Sled						
Multi-Axis Blast Simulator						

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Blast Technologies POC's



Government Point Of Contacts (POCs):

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Blast Mitigation

Exterior and M&S Team Leader

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Blast Mitigation

Interior and Laboratory Team Leader

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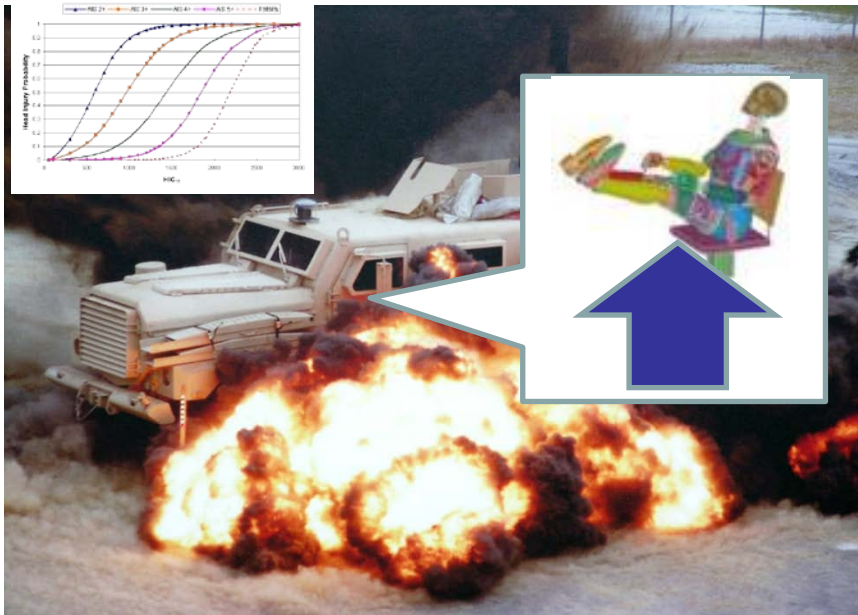
Warrior Injury Assessment Manikin (WIAMan)

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Warrior Injury Assessment Manikin (WIAMan)



Original Schedule & Estimated Costs

MILESTONES	FY12	FY13	FY14	FY15	FY16	FY17
Define Warrior Environment	■					
Cadaveric Testing	◆	■	■	■	■	
Injury Assessment Dev.		■	■	■	■	◆
Guidance to Stakeholders	◆	■	■	■	■	◆
WIAMan Gen 1 Fab, & Test		■	■	■	■	
WIAMan Gen 2 Fab, & Test			■	■	■	◆

Milestone Indicators: TRL or SRL: ◆

Milestone Timeline: ■

Purpose:

Create a Warrior-representative anthropomorphic test device (ATD) and associated biomedically-validated injury assessment tools and a framework for use in LFT&E and vehicle development efforts

Results:

- Secure a significantly robust set of baseline data on blast events and resultant injuries to establish baseline blast event assumptions
- Develop realistic accelerative injury response curves and analytical methods based on actual test, explosive and armor representations
- Develop a test manikin to provide operationally relevant state of the art soldier surrogate
- Data input to vehicle/weapon system design parameters to improve survivability

Payoff:

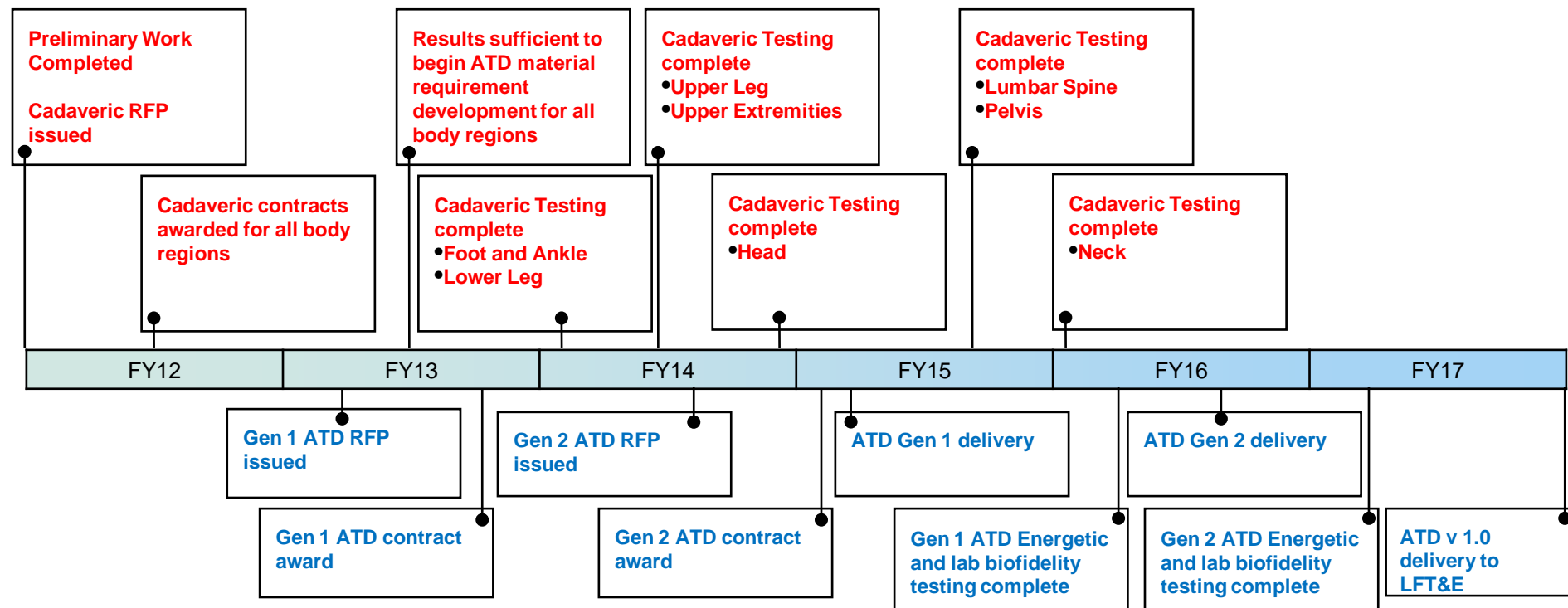
- Increased knowledge of Warrior vulnerability in under body blast events
- State of the art criteria, methodologies & metrics used to assess injuries from accelerative loading sustained during under body blast
- New manikin design to accurately measure vertical accelerative load events
- Vehicle safety and soldier survivability enhancements

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Cadaveric Research and ATD Development Plan Overview



Timeline driven by cadaveric testing requirements

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What is the Problem?

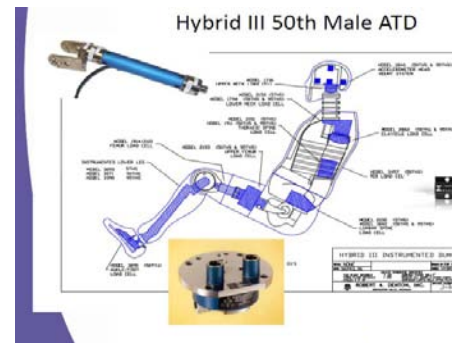
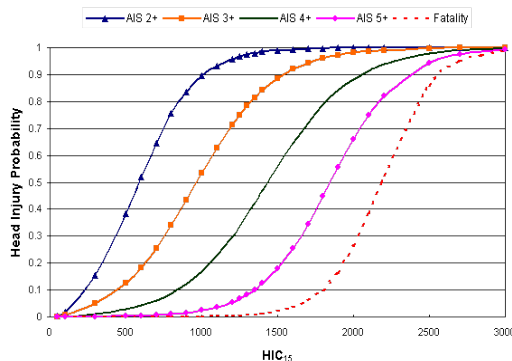
Lack of human injury response data for Under Body Blast events



Blast Test Manikin (Hybrid III) that is anatomically incorrect and was not designed and validated for the extreme vertical loading



LFT&E that does not yield sufficient prediction of Soldier injury during Under Body Blast events



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Project Background



- Cadaveric research that defines human injury criteria for the underbody blast environment (short duration, high magnitude, high rate, primarily in the vertical direction)
- Physical parameters representative of the current soldier population
- Full consideration of the military operational environment
- Instrumentation that satisfies the measurement and data acquisition requirements of the LFT&E environment
- Analyses of injury data from theatre
- Relevant assessment methodologies that can be extended to yield injury assessments at higher fidelities and with higher confidence



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WIAMan



TARDEC POC:

Risa Scherer

Blast Mitigation

Interior and Laboratory Team Leader

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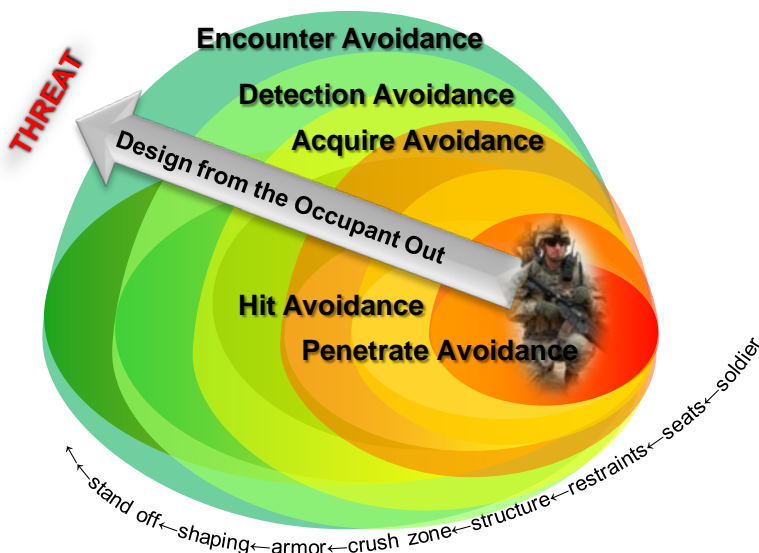
Occupant Centric Survivability (OCS) Project

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Ground Systems Survivability Occupant Centric Survivability (OCS)



Purpose:

The Occupant Centric Survivability (OCS) Project provides the mechanism to develop, design, demonstrate, and document an occupant centered Army Ground Vehicle design philosophy that improves vehicle survivability as well as force protection by mitigating Warfighter injury due to underbody mine blast, underbody Improvised Explosive Device (IED), vehicle rollover, and vehicle crash events.

Products:

This design philosophy considers the Warfighter first, integrates occupant protection technologies, and builds the vehicle to surround and support the Warfighter and the Warfighter's mission. This is accomplished by delivering the following products.

- OCS Concept Design Demonstrator
- Platform Specific Demonstrator #1
 - Alpha (α)
 - Bravo (β)
- Platform Specific Demonstrator #2
- Published Standards: OCS for Army Ground Vehicle Design (Design Guidelines, Test Procedures, and Safety Specifications)
 - Gap Analysis
 - 1st Edition

Payoffs:

- The Occupant Centric Survivability (OCS) Project will provide increased platform survivability and active/passive protection through reduced Soldier casualties and mitigation of injuries related to underbody mine blast, underbody Improvised Explosive Device (IED), vehicle rollover, and vehicle crash events.
- Integrated Superior Occupant Protection Technology Demonstrators
- Improved Vehicle Survivability and Force Protection Quantitatively – Guidelines, Military Standards (MIL-STDs), Test Procedures

MILESTONES – Fiscal Year (FY)	11	12	13	14	15	16
OCS Requirements Development	Reqmt Dvlp		4	5		
OCS Technology Development		Technology Development				
Model Development		Model Development				
Design & Test Standards Development		Standard Development				
Concept Build			Concept Build			
Platform #1 Modification Build (α , β)		5 #1 α Build	#1 β Build			
Platform #2 Modification Build			#2 Build			
Concept Testing & Evaluation				Concept T&E		
Platform #1 Testing & Evaluation (α , β)			#1 α T&E	#1 β T&E		
Platform #2 Testing & Evaluation				#2 T&E	6	



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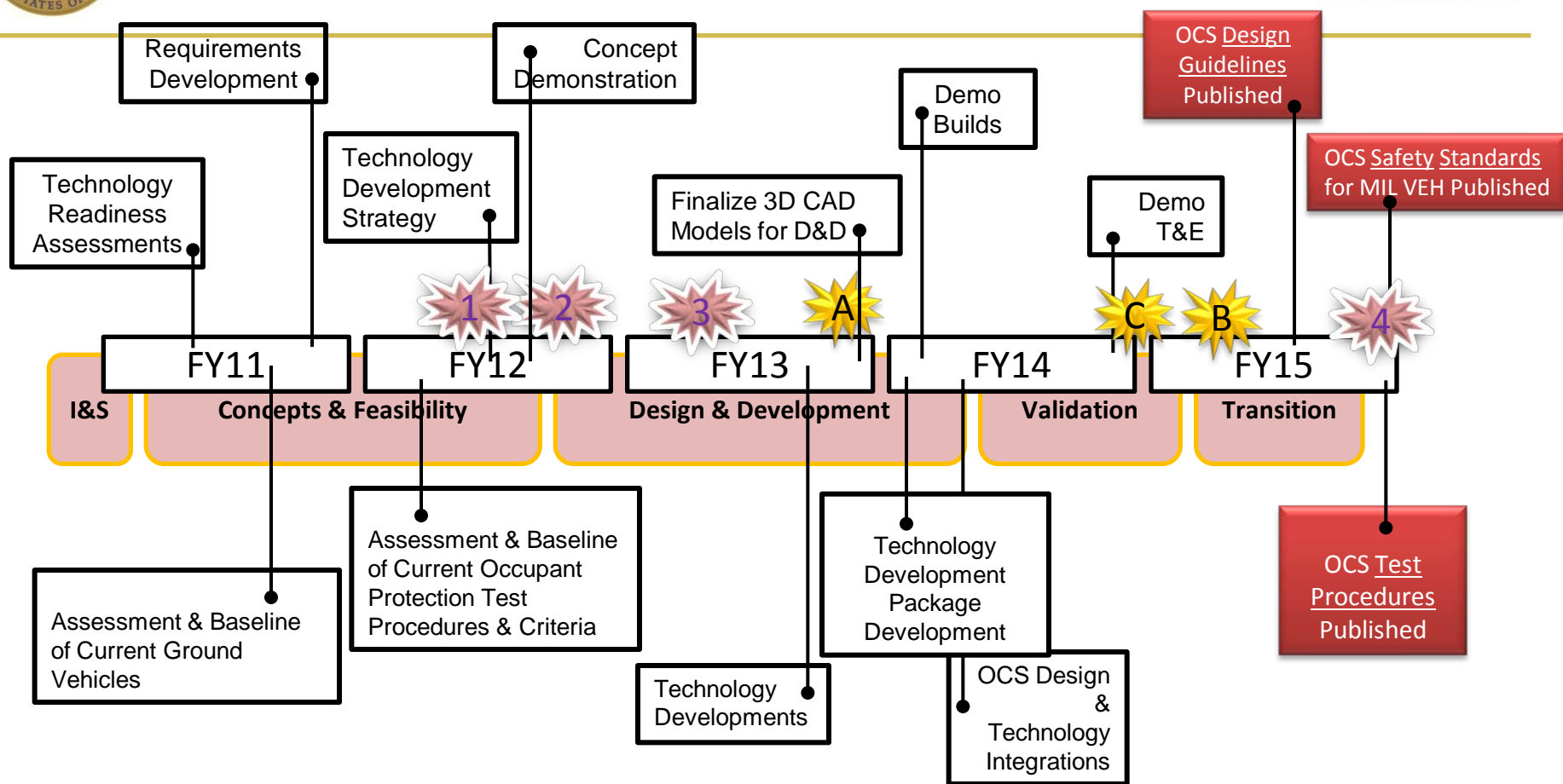
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OCS Timeline at a Glance



- = Technology Drop
- = Knowledge Drop
- = Major Tasks

- Superior Sub-System Technologies
- Design Guideline Assessment and Gap Analysis
- OCS System Level Design Concept following PPDR
- OCS for Army Ground Vehicle Design Guide

- Alpha Demonstrator Technologies
- Bravo Platform Specific Demonstrator Technologies
- OCS Design Concept Superior Technology



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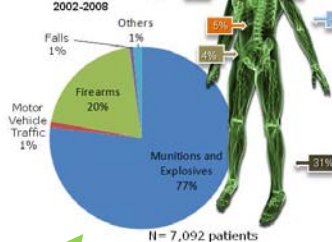
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OCS Technical Approach



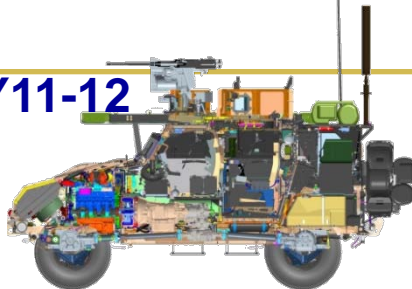
FY11

Cause Agent Breakdown (BI)
2002-2008



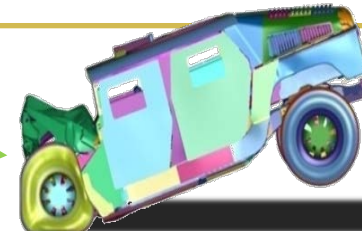
Use current Army Needs, Voice of the Customer, and Injury Data to Define Warfighter Needs and feed System Requirements

FY11-12

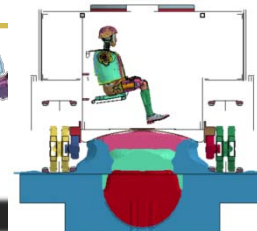


Search current and near-future technology that meets/exceeds requirements, and integrate those technologies into a digital design

FY12



Model design(s) and digitally test for performance.



FY13-14



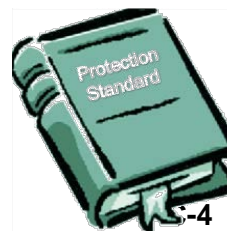
Build OCS Concept Design Demonstrator, Integrate Appropriate Design Features to 2 Current Platforms



FY14



Test OCS Concept Designs and Integrated Platforms to Verify Results and Correlate with Modeling



Produce "Best Practices" and "Design Guidelines" for Future Platform Reference

Kill Avoidance

Designed, integrated, and tested technologies that can improve survivability for the Soldier, and Design Guidelines that can be used for Future Vehicle Designs



Injury Reduction

**FY15
SUCCESS!**

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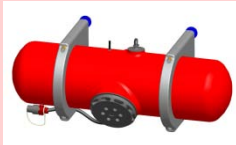
Technical Solutions to Evolving Threats



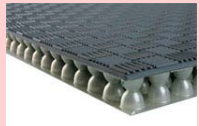
Hull Shaping and Materials -
mitigate the effects of an UB event



Air Bags



Fire Suppression System



Absorption Materials -
reduction of hard-points



Effective Seating - Ergonomics,
Performance, Adjustability, Restraint,
Reconfigurable for litter transport



Innovative Ergonomics -
Ingress/Egress



Restraints



PPE and Gear



Novel Technologies



Challenge to integrate
solutions based on:

- Legacy Vehicle Systems
- Increasing Threats



OCS Mission: D4W – Design for the Warfighter

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2011 Occupant Centric Survivability (OCS) Market Survey



- Posted to FedBizOpps.com and ProcNet (24-Mar-11)
- Survey Closes (21-June-11)

The US Army Tank and Automotive Research, Development, and Engineering Center (TARDEC) Ground Systems Survivability (GSS) is conducting a market survey to identify potential traditional and non-traditional sources and the status of the state-of-the-art technology that provide occupant protection and ground vehicle survivability during an underbody mine blast, underbody improvised explosive device (IED), vehicle rollover, and vehicle crash (front, side, and rear impact). The data gathered in the market survey will help define and influence the trade space and requirements of a follow-on Request for Proposal (RFP) for technology maturation released through the TARDEC Omnibus.

TARDEC is seeking the following technologies to enhance occupant protection and vehicle survivability during underbody mine blast, underbody IED, vehicle rollover, and vehicle crash (front, side, and rear impact): personal protection equipment and gear, interior, exterior, sensing and electronics, fire suppression, retention, and other novel technologies.

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Occupant Centric Survivability



To Document and Demonstrate an Occupant Centric Design Approach for increased Soldier Protection and Vehicle Survivability!

Government Point Of Contacts (POCs):

Regina M. Rogers

OCS Project Lead

Christine M. Wodzinski

OCS Project Deputy

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Blast Summary



- **Blast events is our major threat in theatre**
- **Army is expecting to quickly realize significant improvements in ability to mitigate effects of blast events on Soldiers**
- **We are interested in leveraging what industry has to offer**



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